Mars Exploration Rover Vision Data Analysis: Quantifying Mars Atmospheric Dust Concentration

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Purpose

- Investigate the dust opacity (τ) of Martian dust devils
- Examine the τ distribution as a function of position and time (throughout the development of the dust devil)

Motivation

- Dust in the Martian atmosphere impacts the use and functionality of solar cells in Mars missions
  - Dust affects the spectrum and intensity of solar illumination on the Mars surface
  - In the Pathfinder mission, dust deposition degraded performance at a rate of 0.28% per solar day (sol) during the first month
- Dust devils have removed dust from the MER solar arrays, increasing power output and overall mission lifetime

Atmospheric Analysis

- Navcam rad-cal images are digital light intensity measurements
- Can compare the intensity of light seen through the dust devil with the intensity of light not passing through the dust devil, to determine the concentration of dust in the dust devil
- Beer's Law describes the decrease in intensity due to the opacity, τ, of the dust
  - $I_{dust\ devil} = I_{ground} e^{-\tau}$
- Accounting for light scattered in from the sky, where the total intensity is a weighted combination of light reflected from the sky and the ground:
  - $I_{dust\ devil} = I_{sky} + (I_{ground} - I_{sky}) e^{-\tau}$
  - $\tau = \ln [(I_{ground} - I_{sky}) / (I_{dust\ devil} - I_{sky})]$

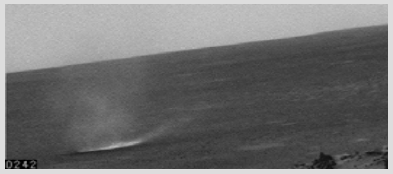
Acknowledgements

- Massachusetts Space Grant Consortium
- Principal investigator Geoff Landis
- NASA Academy Staff

Pictures of the Dust Devils

Radiometrically-Calibrated Navcam Images

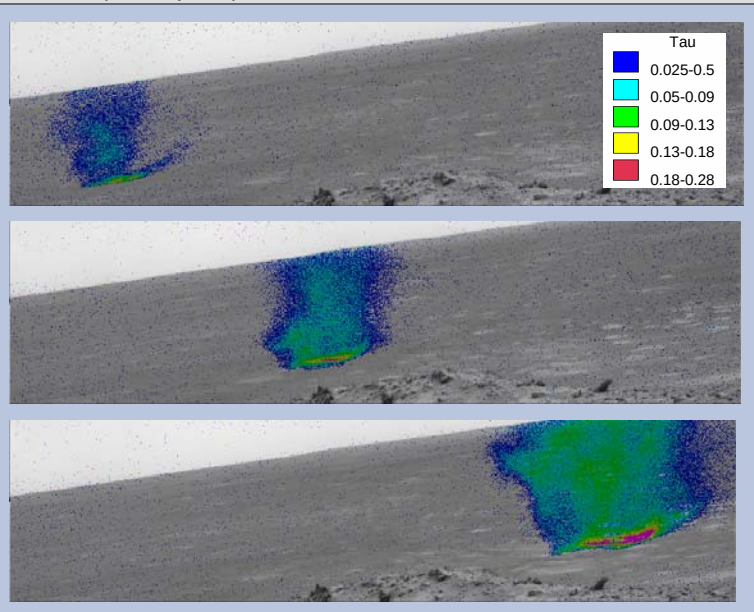
Unaltered



Time-variable features enhanced, image by Mark Lemmon, Texas A&M

Image Processing

- Calculating τ values for each image pixel, displaying the dust devil in false-color corresponding to τ value
- Frame subtraction using two previous frames to filter out noise
  - Pixels that have dust-devil range τ, but have not changed much since the last frame are probably not part of the dust devil

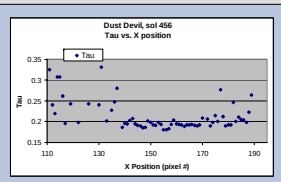


Calculating τ

- To select data points from images, need to look at the enhanced image to see where dust devil is
  - Select pixels for intensity samples: I_{ground}, I_{sky}, $I_{dust\ devil}$ (with ground not sky in the background)
- Then get the actual data values from the non-enhanced image- would be a tedious data selection process
- Developed a simple GUI (Graphical User Interface) to aid in data selection and processing

- Allows user to open an image, select a block of pixels, and then save the data values with the average and a description in an excel-compatible format

- Typical Horizontal Distribution of τ in a dust devil



Next Steps

- Implement more rigorous τ calculations for images, not assuming the same optical properties for the dust devil as the dust suspended in the atmosphere
- Filter noise from the sky differently, currently not able to see dust devil clearly in the sky